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Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams[1]

This standard is issued under the fixed designation D3574; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods apply to slab, bonded, and molded flexible cellular products known as urethane foams. Urethane foam is generally defined as an expanded cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The values stated in SI units are to be regarded as standard.

NOTE 1—There is no known ISO equivalent to this standard, however certain test methods in this standard have similar or equivalent ISO standards and are listed in the scope of the individual test method sections.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers

D737 Test Method for Air Permeability of Textile Fabrics

D3576 Test Method for Cell Size of Rigid Cellular Plastics

D3675 Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source

E162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bonded foam*—a product produced by the adhesion of small pieces of urethane foam to each other with a suitable bonding agent.

3.1.2 *core*—the internal portion of a molded part, free of skin.

3.1.3 *cored foam*—a flexible cellular material containing a multiplicity of holes (usually, but not necessarily, cylindrical in shape), molded or cut into the material in some pattern, normally perpendicular to the foam rise direction, and extending part or all the way through the piece.

3.1.4 *convoluted foam*—a flexible cellular material specially cut into sheets with "egg carton"-like dimples. The dimple peaks and bases can have varied shapes and dimensions.

3.1.5 *flexible cellular product*—a cellular organic polymeric material that will not rupture when a specimen 200 by 25 by 25 mm is bent around a 25-mm diameter mandrel at a uniform rate of one lap in 5 s at a temperature between 18 and 29°C.

3.1.6 *molded foam*—a cellular product having the shape of the enclosed chamber in which it is produced by foaming.

3.1.7 *skin*—the smooth surface layer of a molded foam product, formed by contact with the mold or surfaces.

3.1.8 *slab*—a section of foam that is cut from the internal portion of a large bun.

3.1.9 *urethane foam*—a flexible cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.

3.1.10 *viscoelastic foam*—a specially formulated urethane foam characterized by having slow recovery, low resilience, and high hysteresis loss.

3.1.11 *cell count*—a measurement used to characterize different types of foams based on the size of the individual cells in the foam matrix, typically expressed as either average cell diameter or as the number of cells per linear distance. For measuring cell counts, see Test Method D3576.

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.22 on Cellular Materials - Plastics and Elastomers.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

3.1.12 *clickability*—the ability of a flexible cellular material to recover from the pinching effects of die cutting.

4. Summary of Test Methods

4.1 Unless otherwise specifically stated and agreed upon by the purchaser and the supplier, all tests shall be made in accordance with the methods specified in Sections 9 – 150, which include test procedures for the following:

Tests:		Sections
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X1. Suggested Method for Specifying Flexible Urethane Foams
X2. Suggested Method of Construction for a Roller Shear Dynamic Flex Fatigue Apparatus
X3. Definitions of Terms Used to Describe the Force-Deflection Curve of Flexible Urethane Foam
X4. Suggested Tests for Determining Combustibility of Flexible Urethane Foam. (The combustion tests are given for informational purposes only and are not part of the standard.)
X5. Suggested Method for the Verification of an Inclined Oil Manometer

5. Significance and Use

5.1 The test procedures provide a standard method of obtaining data for research and development, quality control, acceptance and rejection under specifications, and special purposes.

5.2 The data obtained by these test methods are applicable to the material under conditions of the particular test and are not necessarily the same as obtained in other environments in use.

6. General Test Conditions

6.1 Tests shall be entirely conducted at 23 ± 2 °C and 50 ± 10 % relative humidity, unless otherwise specified in the individual test method. The product shall be conditioned, undeflected and undistorted, at 23 ± 2 °C and 50 ± 10 % relative humidity, for at least 12 h before being tested, unless otherwise specified in the individual test method.

6.2 It is recommended for referee purposes that all tests be performed seven days or more after the foam has been manufactured.

6.3 For mechanical tests, it is advisable to carefully select the proper load cell for each test. It is recommended that the expected load for any individual test falls within 10-90 % of the load cell capacity.

7. Sampling

7.1 When possible, the completed manufactured product shall be used for the test specified. Representative samples of the lot being examined shall be selected at random, as required.

7.2 When it is necessary or advisable to obtain specimens from the articles, as in those cases where the entire sample is not required or adaptable for testing, the method of cutting and the exact position from which specimens are to be taken shall be specified. The density and the state of cure can vary in different parts of the finished product, especially if the article is of complicated shape or of varying thickness, and these factors affect the physical properties of the specimens. Also, the density is affected by the number of cut surfaces on the specimen. If a test specimen is die cut, ensure that the sides are not concave and allow sufficient time for complete recovery of the thickness across the full width of the specimen before testing.

7.3 When the finished molded product does not lend itself to testing or to the taking of specimens because of complicated shape, small size, metal or fabric inserts, adhesion to metal, or other reasons, molded test slabs, as agreed upon between the purchaser and the supplier, shall be prepared.

7.4 When differences in test results arise due to the difficulty in obtaining suitable specimens from the finished parts, the purchaser and the supplier shall agree upon an acceptable location from which to take the specimen.

8. Measurement of Test Specimens

8.1 Measure the length and width with a scale, tape, or caliper gauge. Take care not to distort the foam.

8.2 Measure thickness up to and including 25 mm using a height or electronic display gauge with a minimum foot area of 650 mm^2. Hold the pressure of the gauge foot to a maximum of 800 Pa (see Note 2). Thicknesses over 25 mm shall be measured with a height or electronic display gauge, a sliding caliper gauge, or as specified in 8.1. When a sliding caliper gauge is employed, make the gauge setting with the gauge out of contact with the foam. Pass the specimen through the previously set gauge; the proper setting shall be the one when the measuring faces of the gauge contact the surfaces of the specimen without compressing it.

NOTE 2—For soft foams having compression force deflection values less than 1.65 kPa, the pressure on the gauge or compression foot shall not exceed 200 Pa.

8.3 The scale, tape, or gauge shall be graduated so as to permit measurements within ±1 % of the dimensions to be measured.

8.4 Unless otherwise specified, results shall be the mean of the measurements.

TEST A—DENSITY TEST

9. Scope

9.1 This test method covers determination of the density of uncored foam by calculation from the mass and volume of the specimen. The density value thus obtained applies only to the immediate area from which the specimen has been taken. It does not necessarily relate to the bulk density of the entire molded pad.

NOTE 3—This standard is equivalent to ISO 845.

10. Test Specimen

10.1 *Core Density*—A representative specimen of regular shape, circular or square without skins or densification lines, not less than 10,000 mm^3 (~0.61 $in.^3$) in volume, shall be cut from a portion free of voids and defects and as near as possible to the section from which the tension and tear specimens were taken.

10.2 *Section Density*—A representative specimen with skins on the top and bottom surface measuring at least 0.1 m^2 in area by full-part thickness, shall be cut from an area free of voids and defects and as near as possible to the location from which the tension and tear specimens were taken. When these dimensions are not possible, the largest representative portion as agreed upon between the purchaser and the supplier, shall be used.

11. Number of Specimens

11.1 One specimen shall be tested, unless otherwise agreed upon by the purchaser and the supplier.

12. Procedure

12.1 Determine the mass of the specimen to a precision of ±1 %.

12.2 Determine the dimensions of the specimen in accordance with Section 8, and calculate the volume.

13. Calculation

13.1 Calculate the density in kilograms per cubic metre as follows:

$$\text{Density} = M/V \times 10^6 \quad (1)$$

where:

M = mass of specimen, g, and
V = volume of specimen, mm^3.

14. Report

14.1 Report the following information:
14.1.1 Density to the nearest 0.1 kg/m^3, and
14.1.2 Type of specimen, core or section.

15. Precision and Bias

15.1 See Section 151 for Precision and Bias statements.

TEST B_1 —INDENTATION FORCE DEFLECTION TEST—SPECIFIED DEFLECTION (IFD)

16. Scope

16.1 This will be known as the indentation force deflection test and the results as the IFD values. This test consists of measuring the force necessary to produce designated indentations in the foam product, for example, indentations at 25 and 65 % deflections. (See Appendix X3 for additional information).

NOTE 4—This standard and ISO 2439 address the same subject matter, but differ in technical content and results cannot be directly compared between the two methods.

17. Apparatus

17.1 An apparatus having a flat circular indenter foot 200 +3/–0 mm in diameter connected by means of a swivel joint capable of accommodating the angle of the sample to a force-measuring device and mounted in such a manner that the product or specimen can be deflected at a speed of 50 to 250 mm/min. The apparatus shall be arranged to support the specimen on a level horizontal plate which is perforated with approximately 6.5-mm holes on approximately 20-mm centers to allow for rapid escape of air during the test. Special supports for contoured molded pads shall be perforated in the same manner as the flat plate, unless otherwise agreed upon between the purchaser and the supplier. Pads longer than the base plate shall be supported from distortion at the 4.5-N contact force (see 20.3).

NOTE 5—Equipment design and test fixturing can affect the results of this test. As an example, load cells placed below the support plate can experience a bridging effect that likely does not occur in equipment which has the load cell mounted above the indenter foot.

18. Test Specimen

18.1 The test specimen shall consist of the entire product sample or a suitable portion of it, except that in no case shall the specimen have dimensions less than 380 by 380 by 100 mm. If specimens are less than (or different from) 100 mm in thickness, the thickness shall be noted on the test report.

18.2 The IFD values for molded products are dependent on the specimen dimensions. Higher values are generally obtained for specimens that retain all molded surfaces.

19. Number of Specimens

19.1 One specimen shall be tested, unless otherwise agreed upon by the purchaser and the supplier.

20. Procedure

20.1 Place the test specimen in position on the supporting plate of the apparatus. If the product has one side cored or convoluted, this face shall rest on the perforated plate. The specimen position shall be such that, whenever practicable, the indentation will be made at the center of the specimen, except when another location is agreed upon by the purchaser and the supplier.

20.2 Preflex the test area twice to a deflection of 75 to 80 % of the full-part thickness, lowering and raising the indenter foot at a rate of 250 ± 25 mm/min, allowing the indenter to fully clear the top of the specimen after each preflex. For fatigue tests, or in case repeat testing proves necessary, mark the location of the test area by circumscribing the indenter foot with a pen. Allow the specimen to rest for 6 ± 1 min after the final preflex.

20.3 Bring the indenter foot into contact with the specimen at a rate of 50 ± 5 mm/min and determine the thickness while applying a contact force of 4.5 ± 0.5 N to the indenter foot. For super-soft foam, with a 25 % IFD less than 40 N, a reduction of pressure on the indenter foot shall be allowed. Sufficient contact force to make an accurate initial thickness measurement is required. Indent the specimen at a rate of 50 ± 5 mm/min 25 % of this thickness and observe the force in newtons after 60 ± 3 s. Without removing the specimen, increase the deflection to 65 % deflection, allowing the force to drift while maintaining the 65 % deflection, and again observe the force in newtons after 60 ± 3 s.

21. Report

21.1 Report the force in newtons required for 25 % and 65 % indentation or other indentations (see Note 6). These figures are known as the 25 % and 65 % IFD values, respectively. Report length, width, and thickness of the specimen, if non-standard, and the ratio of 65 % to 25 % IFD values (that is, support factor, see Appendix X3).

NOTE 6—Indentation deflection tests, other than 25 % and 65 %, as well as a 25 % return value (25 % RT), may be specified as agreed upon between the purchaser and the supplier. Alternative or additional deflections shall be performed as described in 20.3.

22. Precision and Bias

22.1 See Section 151 for Precision and Bias statements.

TEST B_2—INDENTATION RESIDUAL GAUGE LENGTH TEST—SPECIFIED FORCE (IRGL)

23. Scope

23.1 Cellular foam products have traditionally been checked for indentation force deflection by determining the force required to effect a 25 % deflection. In seating, on the other hand, the interest is in determining how thick the padding is under the average person. Three measurements are called for to meet the requirements of this test method. The force deflection is determined by measuring the thickness of the pad under a fixed force of 4.5 N, 110 N, and 220 N, with a 200 + 3/– 0 mm circular indenter foot.

23.2 This determination shall be known as the Indentation Residual Gauge Length and the measurements as the IRGL values.

NOTE 7—This standard and ISO 2439 address the same subject matter, but differ in technical content; and results cannot be directly compared between the two methods.

24. Apparatus

24.1 An apparatus having a flat circular indenter foot 200 +3/–0 mm in diameter, connected with a swivel joint for applying forces of 4.5 N, 110 N, 220 N and 330 N, shall be mounted over a level horizontal platform that is perforated with approximately 6.5-mm holes on approximately 20-mm centers to allow for rapid escape of air during the test. The distance between the indenter foot and the platform shall be variable to indent the specimen at a speed of 50 to 250 mm/min for thickness measurements. The apparatus shall be equipped with a device for measuring the distance between plates.

24.2 Special supports for contoured molded pads shall be perforated and agreed upon between the purchaser and the supplier. Pads longer than the base plate shall be supported from distortion at the 4.5-N contact force (see 27.2).

25. Test Specimen

25.1 When possible, the finished manufactured product shall be used. In the case of tapered cushions, the location of the area for measurement is to be agreed upon between the purchaser and the supplier. In case a finished part is not feasible for test, 380 by 380-mm specimens of an average thickness are to be cut from the cushion.

25.2 The IRGL values for molded products are dependent on the specimen dimensions. Different values are generally obtained for specimens that retain all molded surfaces.

26. Number of Specimens

26.1 One specimen shall be tested, unless otherwise agreed upon by the purchaser and the supplier.

27. Procedure

27.1 Test the whole test specimen or a minimum area of 380 by 380 mm. Position the specimen in the test apparatus with any cored or convoluted surfaces resting against the perforated bottom plate. Preflex the specimen twice with a 330 N force, raising and lowering the indenter foot at 200 ± 20 mm/min, allowing the indenter foot to fully clear the top of the specimen after each preflex. Allow the specimen to rest for 6 ± 1 min after the final preflex.

27.2 At a rate of 50 ± 5 mm/min, bring the indenter foot into contact with and determine the thickness of the specimen, in mm, with a 4.5 ± 0.5-N load on the indenter foot.

27.3 Apply the 110-N force at 50 ± 5 mm/min with the indenter foot until the force is carried by the specimen. Determine the thickness, in mm, at 110 N after maintaining the force for 60 ± 3 s.

27.4 Without removing the specimen, apply the 220-N force at 50 ± 5 mm/min with the indenter foot until the force is carried by the specimen. Determine the thickness, in mm, at 220 N after maintaining the force for 60 ± 3 s.

28. Report

28.1 Report the specimen thickness, in mm, at 4.5 N instantaneously and at 110 N and 220 N after 60 ± 3 s. These figures are known as the IRGL values, respectively. Report the length, width, and thickness of the specimen.

29. Precision and Bias

29.1 See Section 151 for Precision and Bias statements.

TEST C—COMPRESSION FORCE DEFLECTION TEST

30. Scope

30.1 This test consists of measuring the force necessary to produce a 50 % compression over the entire top area of the foam specimen.